Radiation Health Effects

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Ionization:

Ionization is the removal of one orbital electron from an atom. Since the electron has one negative charge, the atom will consequently be left with a positive charge.

The separated electron and the positively charged atom all called **ion pairs**. A small amount of energy is required to cause ionization.

Charged particles, x and γ rays can cause ionization to the atoms of the absorbing medium. These positive and negative ions may recombine again to form neutral atoms.

If the absorbing medium is a gas, such as air, the recombinations between the positive and negative ions can be prevented by applying an electric field as shown in figure.

In this case, the negative ions will move towards the positive electrode and the positive ions will move towards the negative electrode.

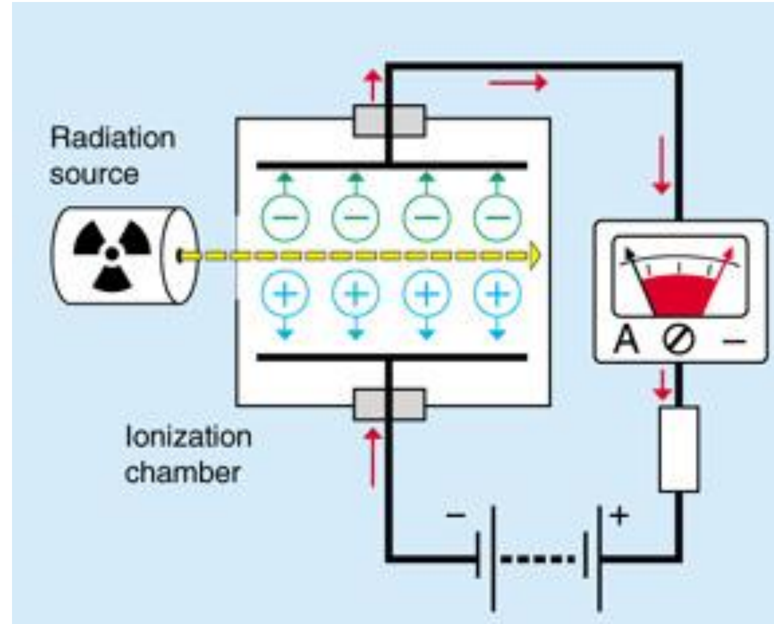


Figure: Ionization Chamber

The flow of ions to the positive and negative electrodes will cause an electric current in the circuit whose intensity will be proportional to the number of ions and hence the intensity of radiation.

This system is called ***ion chamber*** and is used for the measurement of radiation intensity.

Absorbed Dose:

Absorbed dose is a measure of energy deposition in any medium by any type of ionizing radiation.

The unit of the absorbed dose is called the gray (Gy) and is defined as an energy deposition of 1 J/kg

$$1\ \text{Gy} = 1\ \text{J/kg} = 100\ \text{rad}$$


absorbed dose
1 Joule absorbed
1 kg
1 Gray absorbed dose

Dose Equivalent:

It was found that the degree of the biological damage by an absorbed dose is different for the different types of radiation

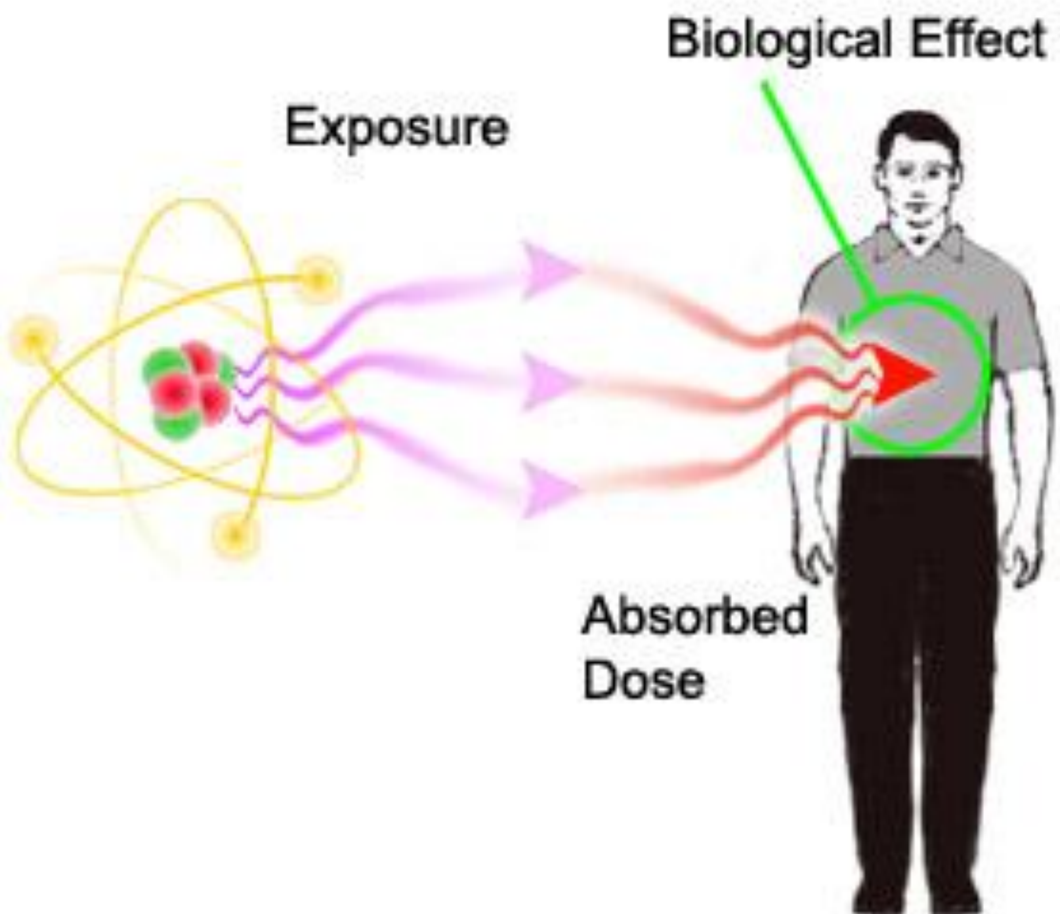
Multiply the absorbed dose of each type of radiation by a **quality factor** Q which reflects the ability of the particular types of radiation to cause the damage. Therefore the dose equivalent in sievert (Sv) or in Rem is used.

Dose equivalent (Sv) = absorbed dose (Gy) x Q dose equivalent

(rem) = absorbed dose (rad) x Q

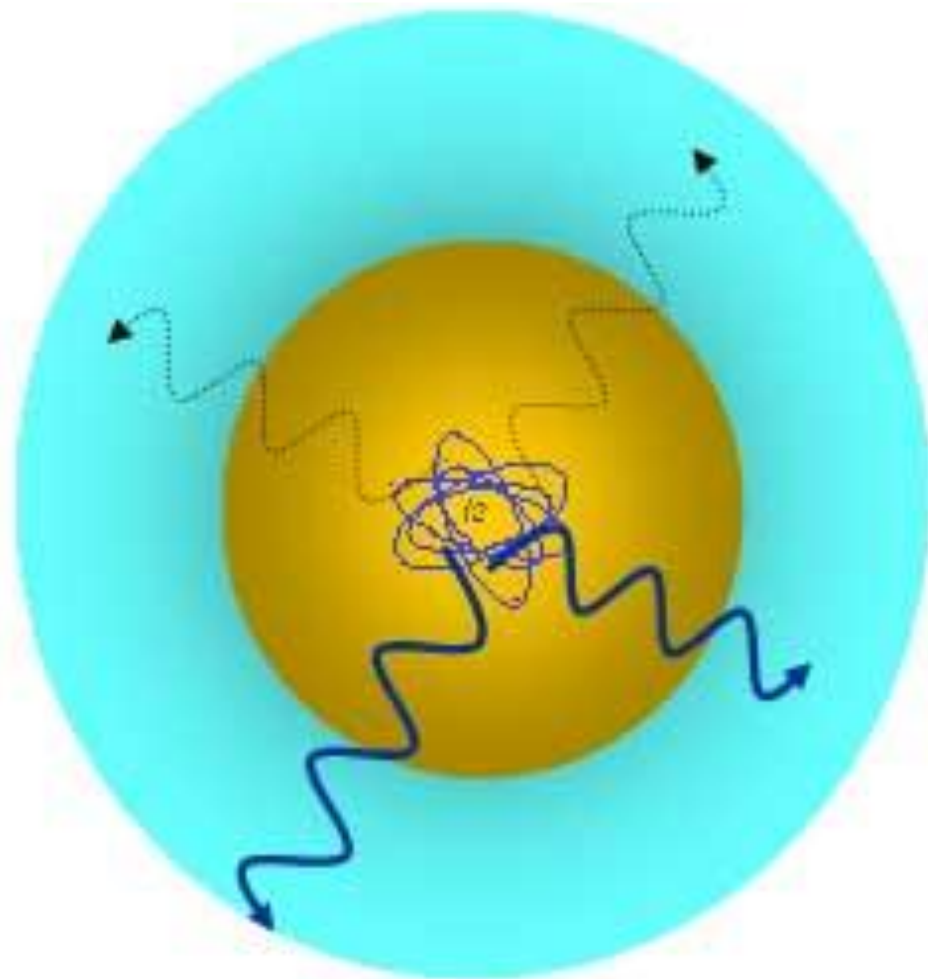
1 Gy = 100 rad.

1 Sv= 100 rem.


Biological Effect
Exposure
Absorbed
Dose

Types of Radiation	**Quality Factor (QF)**
x or gamma rays	**1**
beta particles	**1**
neutrons and protons of unknown energy	**10**
singly charged particles of unknown energy with rest mass greater then 1 amu	**10**
alpha particles	**20**
particles of multiple or unknown charge of unknown energy	**20**

Calculating radiation flux from a point source

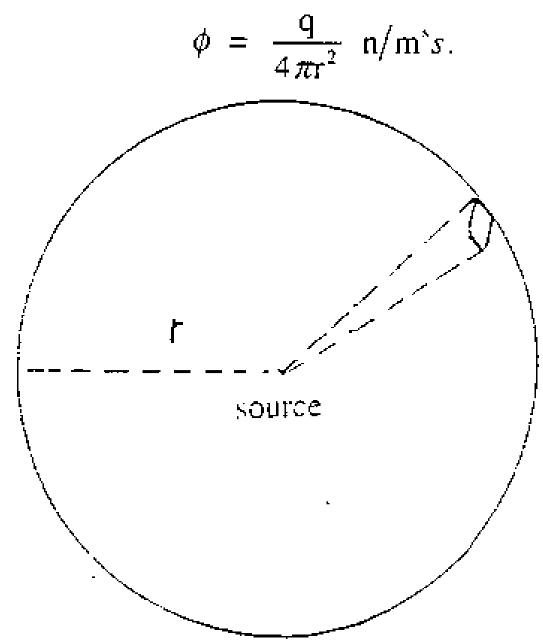


Radiation Flux:

Radiation fields are conveniently expressed by <u>the number of particles or photons crossing an area of 1 square meter in one second</u>. This known as **the flux Q**.

The neutron flux at a distance r from the point source which emits neutrons at the rate q per second by

$$\phi = \frac{q}{4\pi r^2}$$



Radiation flux from a point source

<u>Dose Rate</u>:

<u>The rate at which radiation is received</u>; i.e. Gy/h or m Sv/h.

Dose=dose rate x exposure time

<u>Example :</u>

If a man is working in a radiation field at a dose rate of 10 μSv/h. what is the dose equivalent received by the man during a week if he works 40h/w?

<u>Solution:</u>

Dose = dose rate x time

= 1 0 μSv/h x 40h = 400 μSv

Example :

Calculate the neutron flux at a distance 1 meter from a neutron source which emits *2* x 10^7 n/sec.

Solution:

$$\phi = \frac{q}{4\pi r^2} = \frac{2x\,10^7}{4x3.14x\,1^2} = 1.6x\,10^6\,\frac{n}{m^2.sec}$$

Example:

Calculate the photon flux at 1m from a Cs^{137} gamma source of activity 500 MBq?

Solution:

$$\phi = \frac{q}{4\pi r^2} = \frac{500x\,10^6}{4x3.14x\,1^2} = 39.8x\,10^6\,\frac{n}{m^2.sec}$$

Biological Effect of Radiation

When ionizing radiation interacts with cells, it may or may not strike a critical part of the cell.

Chromosomes to be the most critical part of the cell since they contain the genetic information and instructions required for the cell to perform its function and to make copies of it for reproduction purposes.

There are very effective repair mechanisms at work constantly which repair cellular damage - including chromosome damage.

The following are possible effects of radiation on cells:

1-Cells are undamaged by the dose

Ionization may form chemically active substances which in some cases alter the structure of the cells.

These alterations may be the same as those changes that occur naturally in the cell and may have no negative effect.

2-Cells are damaged, repair the damage and operate normally

- *Some ionizing events produce substances not normally found in the cell. These can lead to a breakdown of the cell structure and its components. Cells can repair the damage if it is limited. Even damage to the chromosomes is usually repaired.*

<u>Cells are damaged, repair the damage and operate abnormally</u>

- If a damaged cell needs to perform a function before it has had time to repair itself, it will either be unable to perform the repair function or perform the function incorrectly or incompletely.

- The result may be cells that cannot perform their normal functions or that now are damaging to other cells.

- These altered cells may be unable to reproduce themselves or may reproduce at an uncontrolled rate. Such cells can be the underlying causes of cancers.

Cells die as a result of the damage

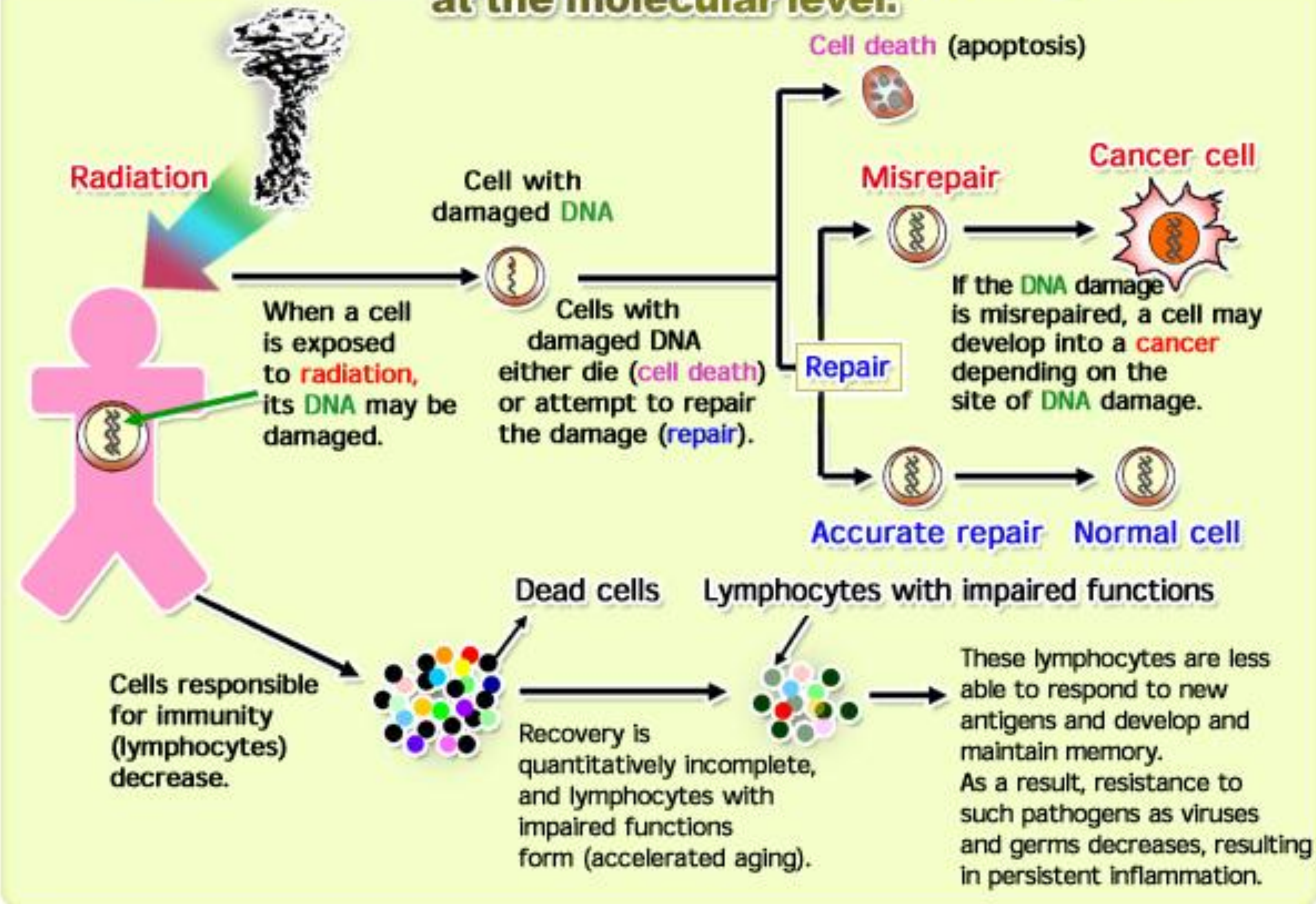
If a cell is extensively damaged by radiation, or damaged in such a way that reproduction is affected, the cell may die.

Radiation damage to cells may depend on how sensitive the cells are to radiation.

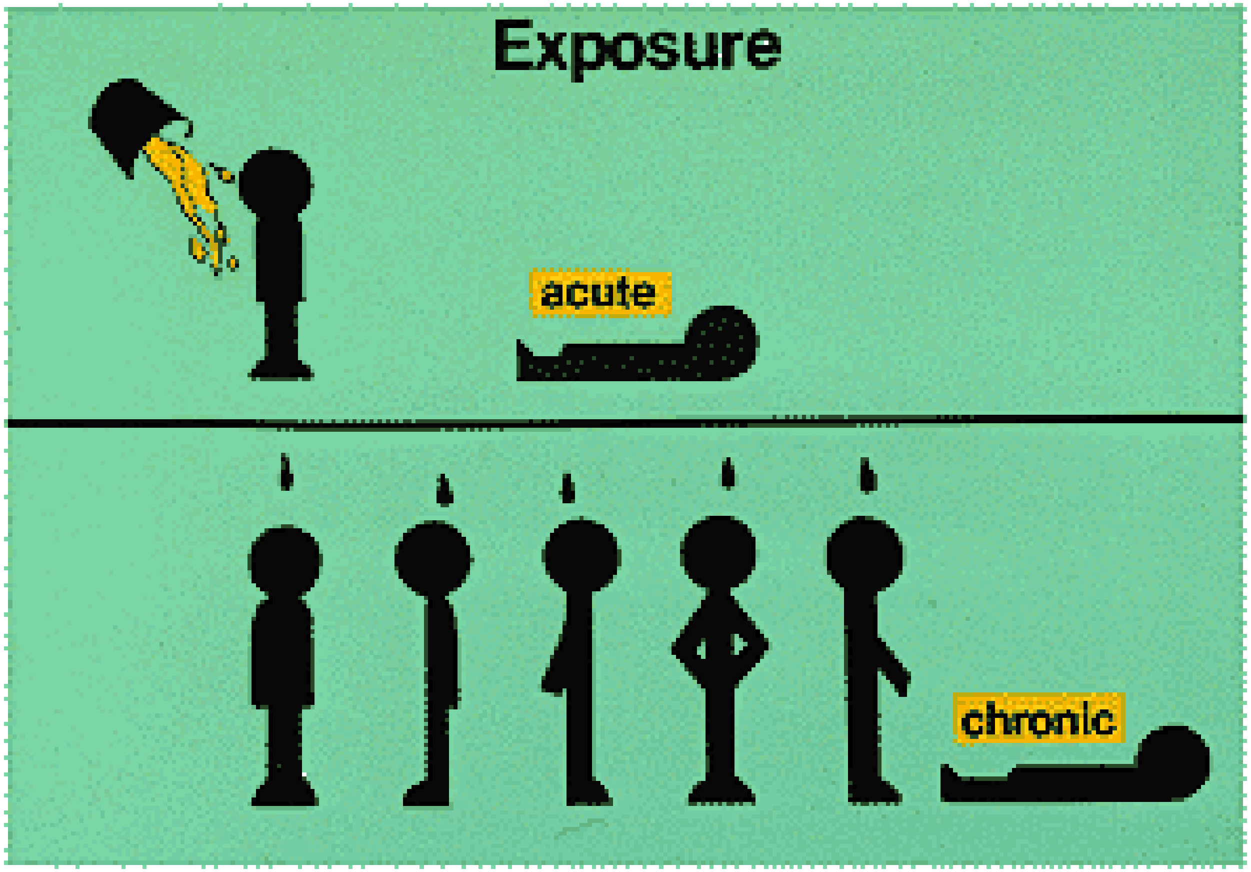
All cells are not equally sensitive to radiation damage. In general, cells which divide rapidly tend to show effects at lower doses of radiation then those which are less rapidly dividing.

Examples of the more sensitive cells are those which produce blood. This system (called the hemopoietic system) is the most sensitive biological indicator of radiation exposure.

Radiation effects on health are being investigated at the molecular level.



ACUTE AND CHRONIC RADIATION DOSE



ACUTE AND CHRONIC RADIATION DOSE

Potential biological effects depend on how much and how fast a radiation dose is received.

Radiation doses can be grouped into two categories, acute and chronic dose.

Acute dose

An **acute radiation dose** is defined as a large dose delivered during a short period of time.

If large enough, it may result in effects which are observable within a period of hours to weeks.

Acute doses can cause a pattern of clearly identifiable symptoms (***Acute Radiation Syndrome)*.**

Ex:1 Blood-forming organ (Bone marrow) syndrome (>100 rad) is characterized by damage to cells that divide at the most rapid pace (such as bone marrow, the spleen and lymphatic tissue). **Symptoms** include internal bleeding, fatigue, bacterial infections, and fever.

EX:2 Gastrointestinal tract syndrome (>1000 rad) is characterized by damage to cells that divide less rapidly.

Symptoms include nausea, vomiting, diarrhea, dehydration, electrolytic imbalance, loss of digestion ability, bleeding ulcers, and the symptoms of blood-forming organ syndrome.

EX:3 Central nervous system syndrome (>5000 rad) is characterized by damage to cells that do not reproduce such as nerve cells.

Symptoms include loss of coordination, confusion, coma, convulsions, shock, and the symptoms of the blood forming organ and gastrointestinal tract syndromes

Chronic dose

- **A chronic dose is a relatively small amount of radiation received over a long period of time.**
- The body has time to repair damage because a smaller percentage of the cells need repair at any given time.
- The body also has time to replace dead or non-functioning cells with new, healthy cells.

- Studies of people who have received high doses have shown a **delayed, or *latent*** effects include some forms of cancer and genetic effects. Since the probability for cancer at high doses increases with increasing dose.

SOMATIC and GENETIC EFFECTS

Somatic effects may be divided into two classes based on the rate at which the dose was received.

- **Prompt somatic effects** are those that occur soon after an acute dose (typically 10 rad or greater to the whole body in a short period of time). Example is the temporary hair loss which occurs about three weeks after a dose of 400 rad to the scalp.

- **Delayed somatic effects** are those that may occur years after radiation doses are received.

Example is the increased potential for the development of cancer and cataracts.

Genetic or *heritable* effects appear as an abnormalities **as a** result of radiation damage to the reproductive cells.

PRENATAL RADIATION EXPOSURE

Embryo/fetus is considered to be at the most radiosensitive stage of human development, particularly in the first 20 weeks of pregnancy.

Potential effects associated with prenatal radiation doses include**:**

Growth retardation
Small head/brain size
Mental retardation
Childhood cancer

Thank you for your attention